



Sveriges lantbruksuniversitet  
Swedish University of Agricultural Sciences

Department of Economics

# Wheat

## – An analysis of variables determining the Swedish price of wheat

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Independent project · 15 hec · Basic level  
Economics and Management – Bachelor's Programme  
Degree thesis nr 852 · ISSN 1401-4084  
Uppsala 2014

## **Wheat – An analysis of variables determining the Swedish price of wheat**

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**Credits:** 15 hec

**Level:** G2E

**Course title:** Independent Project in Economics

**Course code:** EX0540

**Programme/Education:** Economics and Management – Bachelor's Programme

**Faculty:** Faculty of Natural Resources and Agricultural Sciences

**Place for publication:** Uppsala

**Year of publication:** 2014

**Cover picture:** Donna Lasater

**Name of Series:** Degree project/SLU, Department of Economics

**No:** 852

**ISSN:** 1401-4084

**Online publication:** <http://stud.epsilon.slu.se>

**Key words:** *Import, export, reduced form model, regression, trade, wheat*



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## Abstract

Increasing volatility and less political intervention from the CAP in the market price of wheat is making it more difficult than in the past for Swedish farmers to determine the price at which they should sell their wheat. In the past, the Swedish farmer-owned company *Lantmännen* has traditionally set a guideline price for Swedish wheat every year to which farmers could adapt, but ceased doing so last year. Therefore this study sought to identify the parameters on which the price of wheat is dependent on by using a reduced form model. The perspective adopted was that of farmers. The model proved able to identify the main factors determining the annual price fluctuations in wheat, with all variables included having an impact on the wheat price, except export quantity in the previous year. The results is showed in percentage by using the elasticizes and are providing an understanding of the variables affecting the price of wheat, allowing farmers in Sweden to better understand the relative importance of the driving forces of wheat price changes.

## Sammanfattning

För närvarande växer osäkerheten angående vad fluktuationerna på vetemarkanden beror på vilket har gjort det svårt för bönderna att bestämma vid vilket pris det är optimalt för dem att sälja sitt vete. Företaget Lantmännen har alltid satt ett pris på marknaden som har fungerat som en riktlinje, men slutade med det förra året. Syftet med den här studien var att förklara vilka parametrar som påverkar vetepriset. Undersökningen utfördes med hjälp av en reduced form modell som gav varje variabels elasticitet vilket innebär att resultatet visar den procentuella påverkan av varje variabel. Resultatet är av intresse för de svenska lantbrukarna då de kan få en förståelse i hur marknaden fungerar och hur de därefter kan agera för att maximera sin vinst. Studien gav en fördjupad kunskap om vilka variabler som påverkar priset på vete och genom den vetskapen får Sverige en möjlighet att stärka sin position på världsmarknaden. Slutresultatet från undersökningen visar på en ekonomisk situation där alla de undersökta variablerna förutom exportmängden året före har en påverkan på vetepriset.

## Abbreviations

EU	European Union
CAP	Common Agricultural Policy
FAO	Food and Agriculture Organization of the United Nations
OECD	Organization for Economic Co-operation and Development
$R^2$	R-squared
SEK	Swedish kronor
WTO	World trade organization

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## 1 Introduction

In the current situation in Sweden, no single person is in charge of compiling statistics on how the wheat market is progressing, which creates uncertainty in pricing these commodities. Consequently, it can be difficult to guide the market in the right direction using political instruments and to estimate whether Sweden has sufficient food and supplies for its inhabitants and industries. Since Sweden is a part of the EU, they are under the regulations from the common agricultural policies. The objectives of the EU's agricultural policy is to increase the efficiency, ensure a fair standard of living for farmers, stabilize agricultural markets and ensure the food supply for the consumers. The policy is financed by the EU budget and on the wheat market; EU has a minimum price how they guarantee the farmers. This is called intervention price and this price is determined by EU and has nothing to do with demand and supply (eu-upplysningen 2014). The purchased wheat is put in a storage, but this has not happened the last years and EU are phasing out this kind of support and the farmers will instead receive single payments.

As a result of the changing subsidies, the farmers need to learn when it is most suitable to sell on the market (Eklöf 2014). This uncertainty also makes it difficult for farmers to know what is in demand on the market. If farmers do not know what decides the price paid for their produce, they probably do not know what the market wants and what they should produce<sup>1</sup>. The economic question examined in this study was therefore factors determining the price of wheat and how they affect the Swedish wheat market and the trade with other countries. Swedish farmers are good at producing high quality crops, *e.g.* wheat with high protein content, which is in great demand on the international market. However, the complexity of future contracts and the uncertainty regarding whether wheat is a financial instrument or a commodity, depending on the market in which the product is sold, create high uncertainty. By acquiring more information about the market for wheat, farmers can make the market move towards equilibrium, to the mutual benefit of both farmers and grain buyers.

Similar studies regarding investigating the wheat market have been done in other countries. In Chile, there has been a study where they have looked at on how their price support policy work in relation to the international wheat market. The reported results from their survey showed that Chile is a price taker on the market and that there was a high integration between the domestic market and the world market (Diaz-Osorio *et al.* 2011). Another survey done in Pakistan analysed the wheat farmer's economic consequences on the market due to changes in the farmer's economic conditions. Production delays and gross yield were some of the variables examined. The survey result showed that there are lags which are due to difficulties and costs because the farmers are quickly trying to adapt to the changing market (Bhatti 2012). An additional investigation of the wheat market in Australia has been made. In that study, the authors attempted to identify the factors that were important for wheat growers regarding decisions about sales and prices. In the result, the authors have divided the farmers into groups on how they make decisions on the market. Main dividing lines amongst the wheat grower has the division between flexibility and inflexibility, and risk avoidance and risk taking (Malcom & Williams 2012).

### 1.1 Aim

The aim of this study was to investigate factors causing fluctuations in the price of wheat and how the current price affects the Swedish market and trade in this agricultural commodity. The work was performed on behalf of the commercial company Agronomics, which provides

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<sup>1</sup> Katarina Gillblad; founder, Agronomics. Personal interview 2013-10-16

the Swedish agricultural industry with decision support facilitating market-based decisions on the purchase and sale of agricultural commodities.

The market for wheat is relatively large world-wide and in Sweden, since wheat is an important commodity. To limit the scope of the study, the work was restricted to analysis of trade in wheat between Sweden and the rest of the world, since the wheat market is the largest grain market in Sweden and is of great importance for Sweden. The work thus excluded grain crops other than wheat and the markets for these. The analysis was conducted from the Swedish farmers' perspective. The time scale was set to look 20 years back in time, to a particularly interesting stage just before and after Sweden joined the EU in 1995.

The intended target group for the results was farmers in particular, but the results could also be of value to companies which use wheat in their production and to politicians working on instruments linked to the wheat market. By obtaining more market information, politicians can devise the best instruments and help farmers maximise their profits.

The report is organised as follows: Chapter 2 presents the theoretical background to the study, while Chapter 3 describes the choice of economic model and the study variables. Chapter 4 summarises the empirical findings of the analysis. Finally, the discussion and conclusions in Chapter 5 are used to make some suggestions for further research.

Thus, the research question for the study was to look at and identify which parameters that affect the Swedish wheat price on the market. This was done by using a reduced form model with the aim to achieve a deeper understanding on how the wheat market work.

## 2 Background and Literature Review

### 2.1 Historical background

The wheat market has always been important for Sweden. Wheat is a valuable commodity because it is used in several areas as food for both humans and animals, an important commodity in many industries, and is a major trading commodity. In the past, the Swedish farmers' cooperative *Lantmännen* set the guideline price on the Swedish wheat market, and the rest of the market adapted itself to this value. However, last year *Lantmännen* decided to cease setting the price, because all other actors on the market opted to set a slightly higher price. As a consequence, farmers chose to sell their products to the other actors instead, which was not beneficial for *Lantmännen*. In all other EU countries, analysis shows that there is a system whereby a guiding price is set to help farmers decide how they should act to maximise their profits on selling their wheat. As Sweden has chosen to end its price-setting system, an uncertainty has been created on the market, which is not advantageous for farmers in Sweden. It has made it difficult for the farmers to calculate whether they are going to get any profit and has created problems for buyers in setting the right price<sup>2</sup>. Historically, the common agricultural has given a lot of support to the farmers so that the food supply was ensured. This has continued but change into an intervention price where EU has bought the wheat at a minimum price if the farmers were not able to sell the wheat on the market. Due to this scenario, the farmers has always been able to sell their wheat whether there is a demand or not on the market. Currently, EU has decided to phase out the intervention price and instead give the farmers a single payment. This kind of support is considered better because it does not affect the market in the same way that it gives an excess of supply. But it means that the farmers need to learn the market signals in order to make a profit (Eklöf 2014).

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<sup>2</sup> Katarina Gillblad; founder, Agronomics. Personal interview 2013-10-16



## 2.2 Trends

Information concerning previous trends on the market was obtained from reports issued by the Organization for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO). Both organisations are working to explore the agricultural market and to improve trade between countries. According to OECD reports, the trend in the wheat market is that the world market price doubled between 2005 and 2007 and is still rising. The OECD concluded that this is due to an increase in demand, since there are more industries now demanding wheat for their production process. One such industry which has grown strongly in recent years is biofuel production, with Sweden having a factory in Norrköping that only uses wheat for biofuel production. This factory and the biofuel market have a major influence on the wheat market (Bjurling, 2003). The high price of wheat at present could also be due to the fact that weather conditions in the major wheat producing areas of the world have recently been poor, which has reduced yields (OECD, 1, 2011). Wheat stocks are also running low, but in the current situation there are no plans to replenish stocks, since the FAO has food stocks. Taking some future aspects and conclusions into account, the OECD estimates that wheat prices will remain high, but not as high as in 2007 (OECD, 2, 2008). However, by 2020 prices will be higher than the historical mean and world wheat production will increase by 11% compared with that in 2008-2011. The demand for wheat for use in biofuel production is predicted to rise from 0.8% to 2% and the demand on the world market from developing countries will also increase, making the price of wheat increase (OECD, 1, 2011).

The FAO's view on the wheat market is that demand will increase, especially in developing countries, for example China. The FAO predicts that in the future, the demand for wheat will depend on how much change there is in the demand for other grains, for example rice and maize, which are also important grains. Just as the demand affects the price of wheat, the price of other cereals is also predicted to have an effect on wheat prices. Wheat is a product that is used in animal feed, which will also increase demand because developing countries tend to eat more meat as the economy improves (Alexandratos & Bruinsma, 2012).

Wheat production is the second largest agricultural production sector in Sweden, with only milk production being larger (FAO, 2014). Sweden produced  $2.29 \times 10^6$  tonnes of wheat in 2012, with an estimated value of  $117 \times 10^7$  Swedish kronor (SEK) (FAO, 1, 2014). Due to the Department of Agriculture are Sweden self-sufficient in wheat and can therefore export the commodity. The consumption of wheat in Sweden has in the last years been on a stable level and the department of Agriculture predict it to stay stable except of an increase in demand from the industries.

## 2.3 The Swedish market

Wheat is an important commodity in Sweden and is grown on almost 15% of Sweden's arable land. However, the production in Sweden has been fairly stable since 2001, fluctuating between 2 million and 2.5 million tonnes per year (Figure 1). Exports from Sweden have also remained at a stable level of 400 000 tonnes per year (Figure 2). However, wheat imports into Sweden have increased dramatically in the last couple of years (Figure 2). As mentioned, Sweden has an ethanol production industry in Norrköping, which could be one of the reasons why wheat imports have increased so much. The industry in Norrköping is expanding and domestic wheat production is constant (Figure 1), this means that Sweden has to import more. Moreover, ethanol production does not require such high quality wheat, which means that the factory can import cheaper wheat. In an analysis of the Swedish wheat market by (Eklöv *et al.* 2012), the static yield level is attributed to the weather, because the total arable area in Sweden has increased in recent years, which should have led to higher domestic wheat production. In addition to ethanol production, wheat is used primarily in domestic food

production and alcohol production (Eklöv *et al.*, 2012). After ethanol production, which now uses 130 000 tonnes per annum, the vodka manufacturer *Absolut* is the largest buyer in Sweden of wheat. It buys around 100 000 tonnes of wheat every year, through contracts with 400 farmers in southern Sweden (theabsolutcompany 2014).

## Total wheat production in Sweden

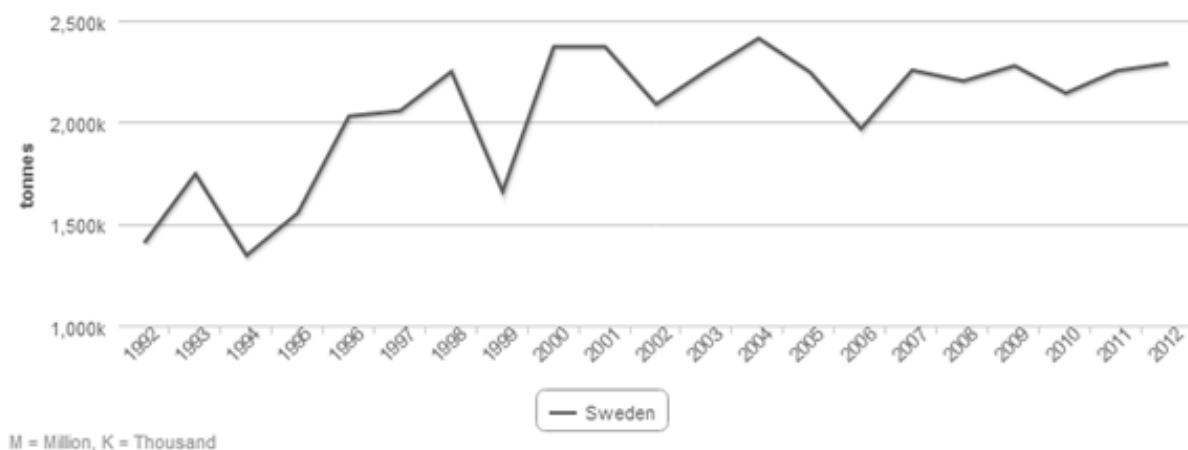


Figure 1. Total annual production of wheat in Sweden 1992-2012 (FAO, 2, 2014).

The company Agronomics has conducted an analysis of the Swedish wheat market. Their report shows that there is lower demand for wheat in animal production and that the price of wheat will have to decline or otherwise the demand will remain low. The wheat growing area increased in 2013-2014 and Sweden is predicted to harvest more wheat in 2014. The current price forecast for wheat is that prices will stay stable or decline slightly (Hintze-Gharres, 2014).

The main countries to which Sweden exports wheat in the EU are Denmark, Germany, the Netherlands, Spain and Finland (Figure 2). However, Sweden also exports similar amounts to some North African countries and the FAO is predicting that the developing countries will demand more wheat for food production in future (Eklöv *et al.* 2012) (Figure 2).

## Total export and import in Sweden

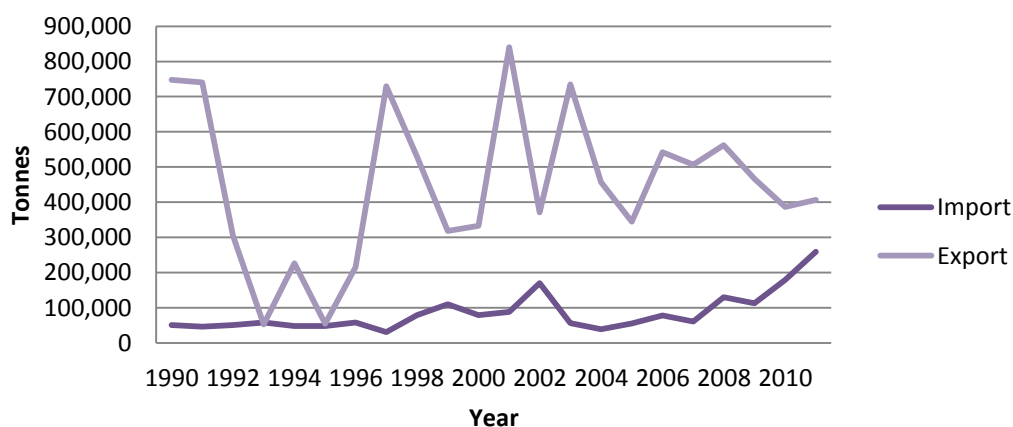


Figure 2. Total annual exports and imports of wheat from Sweden, 1990-2011 (FAO, 3, 2014).

Looking at the wheat prices fluctuations in the Scandinavian countries and comparing them to Sweden, they are similar with the exception for Norway (Figure 3). This is probably due to the fact that Norway is not a part of the EU. Finland joined EU 1995 and there is a difference in the Finnish price after they become a part of the EU. All the countries that are part of EU have similar price and does probably not have much competition from these countries.

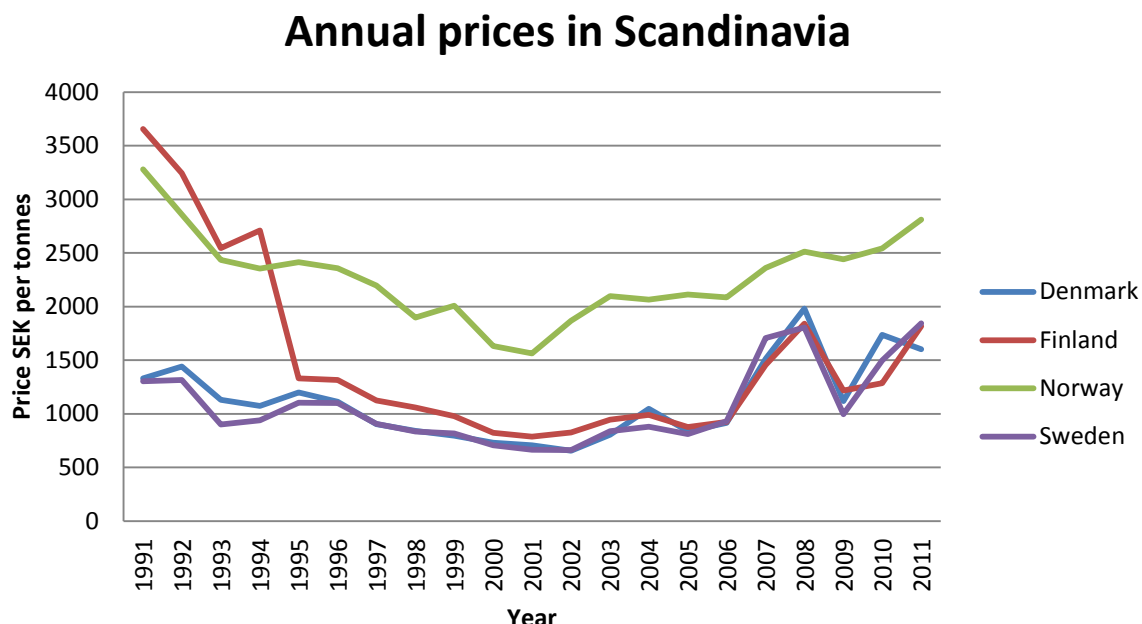
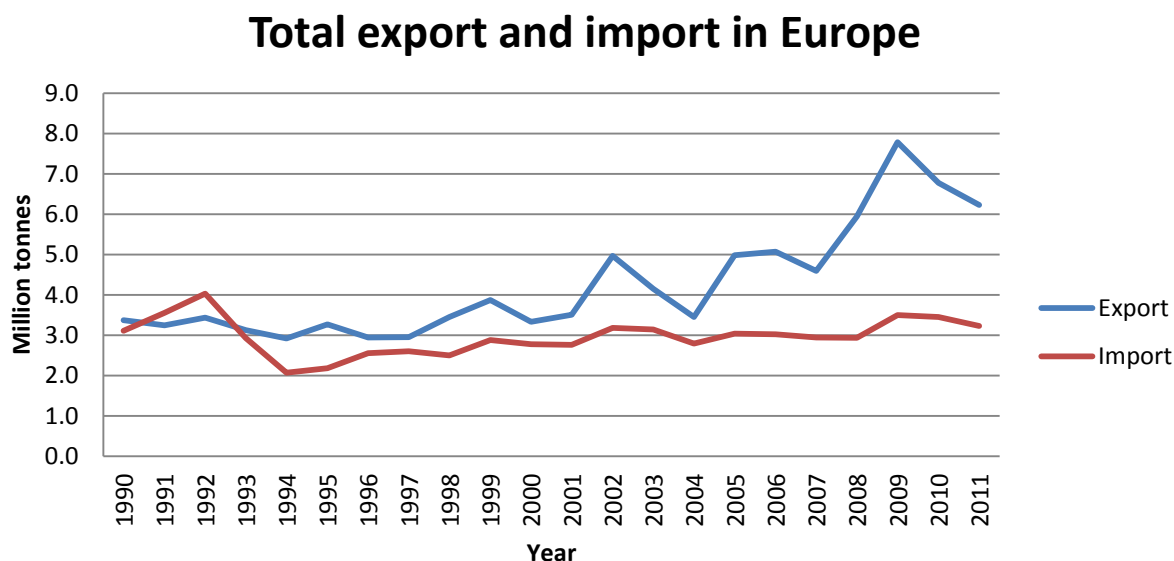


Figure 3. Annual prices of wheat between 1991 and 2011 in the Scandinavian countries (FAO, 5, 2014).

## 2.4 The global market

As Sweden is part of the EU, the EU is a major market force on the Swedish market. Therefore, a closer analysis of the global market is also necessary, as it has an impact on the Swedish market. Sweden has most contact with the European market. Figures 4 and 5 show how much wheat Europe has imported and exported in recent decades, during which time there has been fairly stable production, but fluctuating exports. According to analyses by the Swedish Board of Agriculture, the decline in European wheat exports from 2009 and forward is attributable to higher consumption and trade within the EU, *i.e.* the wheat is staying within the EU countries and there is no trade with other countries (Eklöv *et al.*, 2012).



*Figure 4.* Total annual imports and exports of wheat in the European Union, 1990-2011 (FAO, 3, 2014).

Within the EU, 37% of total arable area is used for growing wheat, mainly because the climate is suitable for growing this crop. The large amount grown makes wheat an important crop for the EU and there are also historical factors whereby most European countries have grown wheat and used it in various applications. As mentioned earlier, both the FAO and OECD are predicting an increase in demand for wheat from developing countries, but this is not evident in the statistics at the moment. One of the most common factors influencing import and export is the quality of the wheat, called intra industry trade. Low quality wheat is often exported from Sweden to Europe as animal feed and high quality wheat is imported into Sweden as human food. Therefore export and import amounts can vary quite widely depending on what is in demand (Kennedy & Koo 2005). Looking at the seasonal perspective, the demand varies depending on whether it is the harvest season in Europe or not. If it is not the harvest season, then the trend is that the price increases.

The main exporting country in the world is the United States of America (USA), as can be seen from the list of top exporting and importing countries in Figure 5. The USA is a large country, both in terms of area and number of inhabitants and large fields are used for wheat production. It is interesting that the domestic use of wheat in the USA has declined in recent years, due to less demand. This decline in demand is thought to be due to recent publicity about the health risks of eating wheat and therefore a change in the consumption patterns of some groups within the US population is underway. According to the US Department of Agriculture (USDA), average consumption has dropped, from 133.4 pounds per person in 2000 to 132.5 in 2011 (Liefert & Vocke, 2013). As shown in Figure 4, there has been a decline in European exports, which could be due to the decrease in demand from the USA, which is a major country with a significant impact on the wheat market. The decline in European exports could also be due to the USA exporting more, because of the decline in domestic demand.

In addition to the USA, the other top exporters and top importers in the rest of the world (Figure 5) are mostly large countries and are working as influential actors on the market, allowing them to have a major influence on the market. Thus Sweden is often dependent on

what is happening on their markets. For example, if there is bad weather in the USA, Sweden can count on the price of wheat rising, because the world supply will decline (FAO, 3, 2014).

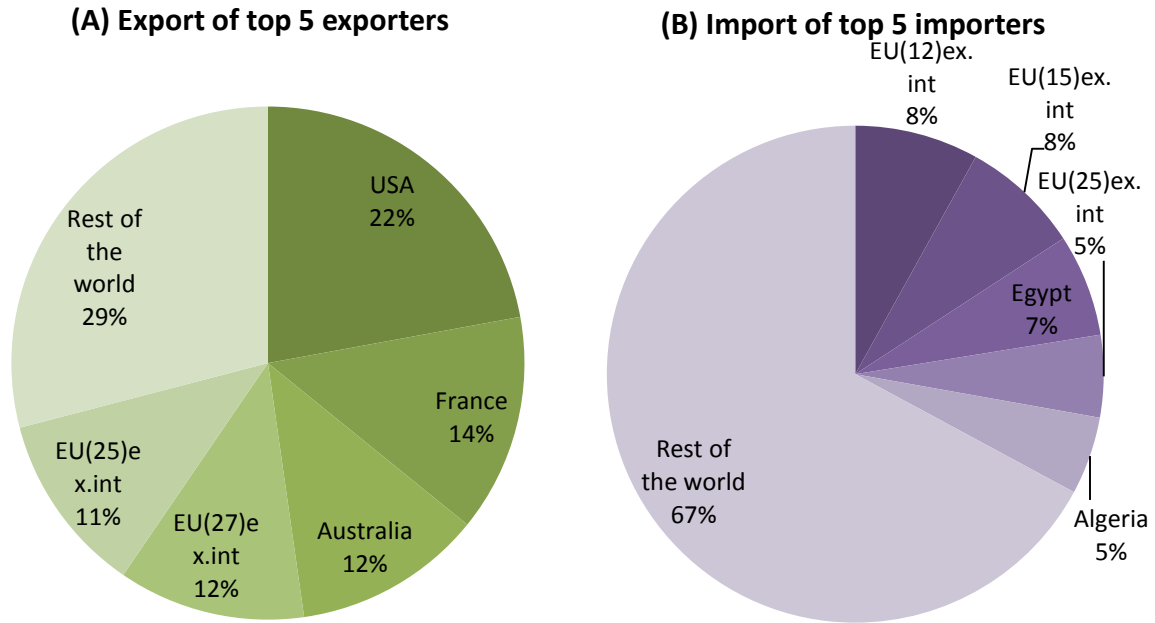


Figure 5. (A) Top wheat exporting countries and (B) top wheat importing countries in the world in 2011 (FAO, 3, 2014).

### 3 Theory: Reduced form Partial Equilibrium Model

The scientific basis for the present study is that there is uncertainty regarding factors determining the price of wheat. To investigate the relationship between the variables potentially affecting the price of wheat, a reduced form model was developed based on the partial equilibrium representation of supply and demand curves in the market for wheat in Sweden. And unwanted show of the reduced form partial equilibrium model is that it allows estimation of key parameters, such as elasticities, within multiple regression. Involving multiple regression was developed. In the reduced form model, the functions for demand and supply are applied as follows:

---


$$Q_d = f(P_t, Z) \quad \text{(equation 1)}$$


---

where  $Q_d$ =quantity demanded,  $P_t$ =price and  $Z$ =factors with an impact on the quantity demanded.

---


$$Q_s = g(P_t, H) \quad \text{(equation 2)}$$


---

where  $Q_s$ =quantity supplied,  $P_t$ =price and  $H$ =factors with an impact on the quantity supplied.

Both these equations are linear, so the quantity demanded varies inversely with the price. A higher price gives a decrease in demand and makes the supply more profitable for the farmers. These two functions give the relationship:

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$$Q_s = Q_d \rightarrow f(P_t, Z) = g(P_t, H) \quad (\text{equation 3})$$

---

The relationship between supply and demand can also be described as the reduced form model where the equations are solved for the endogenous variable:

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$$P_t = k(Z, H) \quad (\text{equation 4})$$

---

where  $P_t$ =price and  $H$  and  $Z$  = variables with an impact on price in the reduced form model.

Concerning the vectors  $Z$  and  $H$  it is expected that production quantity, exports, imports etc. will likely be influential factors contained in these. If there is good quantity on the produced wheat, the price is likely to go up. Large quantities exported means that supply will decrease and the price is expected to go up since the supply is decreasing. For large amounts imported will the supply increase and the price decrease in Sweden. The independent variables investigated here as potential variables affecting the price of wheat are explained in Table 1.

Here a dynamic process will appear and the prices will adjust until supply equals demand and the market is in equilibrium. These variables could include the demand for wheat due to the production of ethanol or other industrial demands. The reduced form model aims to give a good approximation of factors determining the price (Jarrow & Potter, 2004).

The reduced form model is based on partial-equilibrium analysis, where only one market is examined in isolation, *i.e.* prices and quantities of other goods are assumed to not affect the market for wheat in a way that would have to be taken into account (Figure 6). By doing this, the clearance on the wheat market is obtained independently from other markets. Partial-equilibrium analysis makes it possible to examine one single market. It is a powerful model, but due to its assumption that there is only one product examined hold all the other constant, it does not show the real-world scenario, but rather an approximation of it. Figure 6 shows where the equilibrium will be on the wheat market, *i.e.* where supply and demand is equal (Perloff 2008:324).

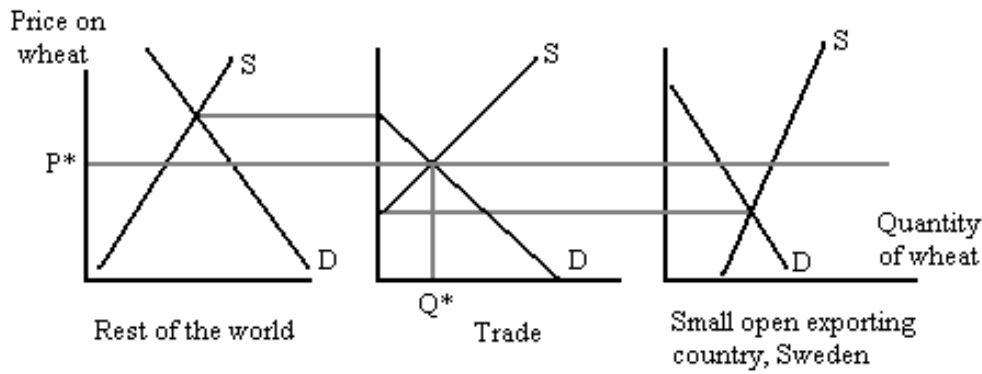


Figure 6. The partial-equilibrium graph between Sweden and rest of the world. The equilibrium price are  $P^*$  and the equilibrium quantity are  $Q^*$  where supply and demand are equal each other.

## 4 Method: Econometric Estimation of Elasticities

### 4.1 The reduced form model

The reduced form model was determined as a log-log multiple regression. This method was chosen because essentially nonlinear are relationships between variables can be estimated within a linear framework, and the obtained regression coefficients can directly be interpreted as elasticities. The model is intended to explain the dependence of one variable, in this case the price of wheat, on more than one explanatory variable (Gujarati, 2009). Such a model is suitable for use in this case, because the results show the effect of every variable separately (Funk, 2011). The regressions were performed using the program Gretl, while Microsoft Excel was used to help structure the data.

In a multiple regression, the dependent variable depends on several variables (see equation 5). The equation can contain different numbers of variables depending on how many there are.  $Y$  is the dependent variable, which has an effect if one variable, for example  $X_{1i}$ , is changed while all other variables are held constant. This means that the multiple regression model isolates the effect on  $Y$  of every single variable. The coefficient  $\beta_1$  describes the effect on  $Y$  of a unit change in  $X_1$  when holding everything else constant, *i.e.* it is the slope of  $X_1$ .

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$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} + u_i, i = 1, 2 \dots n \quad (\text{equation 5})$$


---

where  $\beta_0$  is the intercept,  $u_i$  is the equation error term and  $i$  is the  $i^{\text{th}}$  of the  $n$  observations in the sample.

Performing a regression for equation 5 gives the estimated value of the unknown parameters with the information collected. The difference between the observed value, the dependent variable and the predicted value is called the residual (see figure 7).

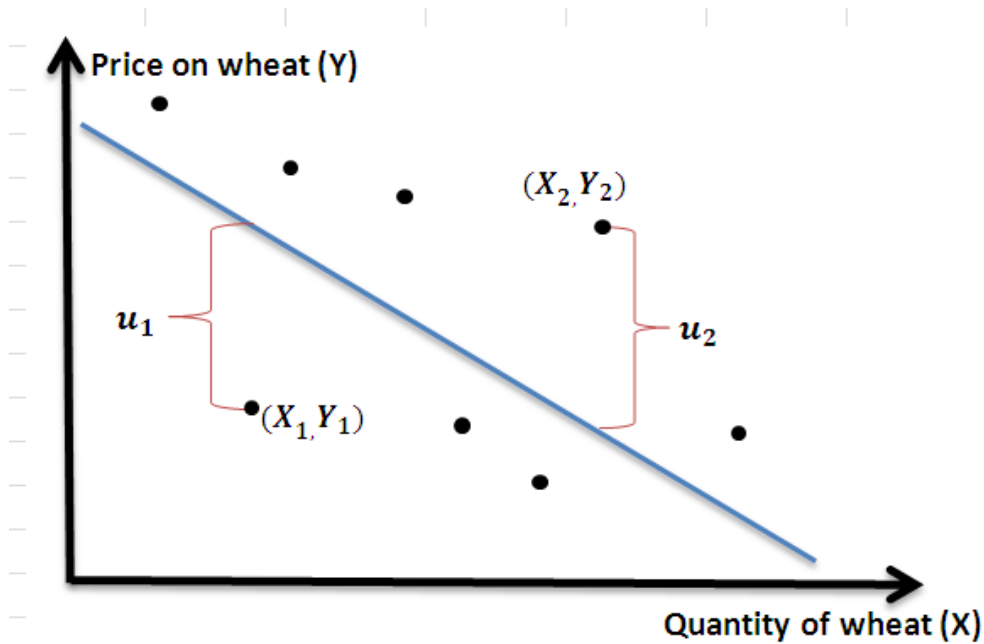


Figure 7. Difference between the actual value and the fitted line. In the best case scenario, the difference should be as small as possible.

The relationship between the dependent and independent variables is often not perfect. There is often unexplained variation in the dependent variable, caused by some kind of random error. Thus the results will only give an overview of the real world, and not explain it fully. However, there are some ways to evaluate how trustworthy the regression is, as explained in the following paragraphs.

When using a multiple regression analysis, four assumptions are made. These assumptions are necessary in order to perform the regression and help understand whether the regression will give useful estimates. If the assumptions do not hold, it can be useful to see why this is the case and how the regression can be improved. The four assumptions are:

1. The conditional distribution of the error term given  $X_{1i}, \dots, X_{ki}$  has a mean of zero. This means that the value of the dependent value can be below or above the regression population line, but is on average on the population regression line. This means that the error term is on average zero.
2. The observations in the sample are independent and identically distributed random variables. This assumption will hold automatically if the sample is random. When time series data are used this assumption could be incorrect, since there could be a correlation between the variables, violating the independence part of this assumption. This is important to bear in mind.
3. Large outliers are unlikely. If there are large outliers, the results could be misleading because these outliers have too great an impact.
4. There cannot be perfect multicollinearity. The regression is multicollinear if one of the regressors is a perfect linear function of the other regressors. If there is multicollinearity, the results will be misleading (Stock & Watson, 2007:203).

#### 4.1.1 Probability value

The probability (P) value indicates whether the results of the regression are significant or not, *i.e.* it is the probability of observing a more extreme value than the value recorded, given that the null hypothesis of no relationship between the variables is true. The value of P lies between 0 and 1, where a small value (often  $<0.05$ ) indicates strong evidence against the null



hypothesis, so it is rejected. A large P value, generally  $>0.05$ , indicates weak evidence against the null hypothesis and it is not rejected. The present regression used the  $P<0.05$  level, which is the usual significance level (Stock & Watson, 2007:73). It means that the results observed occur by random five times out of 100, *i.e.* that there is a 5% chance of being wrong when an explanatory variable is reported to be significant, which can be deemed sufficiently unlikely. The conclusion is then that the results depend on a certain factor, for example good weather gives higher returns in terms of yield. The level of the significance is determined by the purpose of the t- test. (Stock & Watson, 2007:79). In the present analysis, the level of significance was set at 5%, which means there is 5% chance of being wrong when an explanatory variable is reported to be significant. The regression model tests each variable separately to see if the variable is statistically different from zero. A low P-value indicate that the null hypothesis can be rejected and the explanatory variable has an impact on the dependent variable.

#### **4.1.2 R-squared and the adjusted R-square**

The goal with the regression is to explain as much as possible of the variation in the dependent variable. The R-squared ( $R^2$ ) statistical parameter has a value that varies between 0 and 1 and indicates how well the regression explains the value of the dependent variable. In other words, it is a measure that indicates how much variation there is. If  $R^2$  is 1 or close to 1, the regression line fits the data perfectly and the independent variable explains the dependent variable. However, if  $R^2$  is closer to 0, the independent variable does not explain the variation in the dependent variable (Stock & Watson, 2007:200).

For each new explanatory variable added, R-square will increase even if the new variable does not make the model better. To correct this the  $R^2$  can be reduced by some factor and that is called the adjusted  $R^2$ . The adjusted  $R^2$  does not necessarily increase when a new variable is added. Just like  $R^2$  the adjusted  $R^2$  has a value between 0 and 1 and a higher value is better when a low one. A high value indicates that the regression explains most of the variation in the dependent variable (Stock & Watson, 2007:201).

#### **4.1.3 Predicted value: forecasting the price of wheat**

The aim of this study was to determine whether there are any variables that could help explain the fluctuations in wheat prices and how to predict the future price. Therefore, after the regression was made, the predicted value was calculated from the estimated regression equation (equation 6). The estimated coefficients and the averages for the variables were entered into the equation. A good model could give clear predictions about the future reality as long as the causal relationships implied by the model remain the same and likely future values for the corresponding explanatory variables can be obtained.

#### **4.1.4 Heteroskedasticity**

Heteroskedasticity appears when the variance of the error term is not constant; *i.e.* when the value of the independent variable increases or decreases there will be unexplained variation in the independent variable. The presence of heteroskedasticity can invalidate the significance of the regression and the regression will not give the most accurate estimates. Therefore when the present regression was made, robust standard error was used to correct standard errors in the model (Stock & Watson, 2007:160).

### **4.2 Logarithms**

In the study, all the explanatory variables and the dependent variable were log-transformed to show changes as percentages. This way of predicting values is often used when determining prices, which this study aimed to do. The model used was a log-log model (equation 6), where both Y and X were specified in logarithms. The regression was:

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$$\ln(Y) = \beta_0 + \beta_1 \ln(X_1) + \dots + \beta_k \ln(X_k) + u_i, i = 1, 2 \dots n \quad (\text{equation 6})$$


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As this equation shows, a 1% change in X is associated with a  $\beta_1$  % change in Y. Thus the coefficients will give the percentage change in Y if X changes by 1%. Since  $\beta_1$  is the percentage change in Y associated with a 1% change in X,  $\beta_1$  is the elasticity of Y with respect to X. For example, a 1% increase in total output of yield will give a  $\beta_1$  percentage increase in the total price of wheat. The log-log model often gives a higher  $R^2$  value, which means that more variation in Y is explained by the variables (Stock & Watson, 2007:272).

### 4.3 Lag variables

In the regression all the variables were also lagged. This means that for every existing independent variable, one extra variable was added. The four explanatory variables were lagged one year behind, a procedure which is quite common when using time series data. This was done because an effect of a variable is usually not seen in the price straight away. The model for lagged variables is shown in equation 7 (Adkins, 2014).

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$$Y_i = \beta_0 + \beta_1 X_{ti} + \beta_2 X_{t-1i} + \dots + \beta_k X_{t-1} + u_i, i = 1, 2 \dots n \quad (\text{equation 7})$$


---

The meaning in using lagged variables is that some effects are not shown in the same year, for example planting decision, harvest time and sales of wheat. For example, a decision to cultivate more land for wheat will have an effect in the next year in the price.

### 4.4 Choice of economic data sets

There are three kinds of data sets that can be used when performing an econometric analysis. These are time series, cross-sectional and pooled. A brief explanation of these is given below.

#### 4.4.1 Time series data sets

Time series data are a set of observations taken at different times. The data need to be stationary in order to have proper statistical properties. This means the variances, covariances and means cannot depend on the time period (Adkins, 2014). For example, the variance in imports of wheat to Sweden cannot differ between years. The time series data are always collected at regular time intervals and these intervals can be daily, weekly, monthly or yearly. The data give information about changes in the given variables over time and allow forecasting of the future values of those variables.

#### 4.4.2 Cross-sectional data sets

Data collected by observing one or more variables collected at the same point in time are called cross-sectional data. Cross-sectional data are often used to compare differences within a subject, for example a population. The cross-sectional data show the relationship between a numbers of variables by studying the differences during a single time period (Adkins, 2014).

#### 4.4.3 Pooled data sets

Pooled (panel) data are data containing more than one entity and are collected during different time periods. In other words, they are a combination of time series and cross-sectional data sets. For example, consumption and price of a commodity are a panel data set. The panel data set is useful when examining economic relationships from many different entities in the data set and the change over time of the variables for each entity (Stock & Watson, 2007:13).

#### 4.5 Choice of explanatory data

When investigating the explanatory variables of wheat, the present regression used time series data sets. This allowed the regression to incorporate the factors during certain years and to produce results providing helpful information about forecasting the future price of wheat (Gujarati, 2009). The overall aim of the work was to evaluate the future price of wheat and therefore time series gave the best results. The time interval selected was yearly intervals in order to get the best results, because during the harvest year the prices are often already set due to solid variables and therefore not interesting to analyse. It was assumed that more reliable results could be obtained by including a long period and that the outcome would provide the information required by farmers (Jarow & Potter, 2004).

The data used in the study were observational data, *i.e.* data obtained by observing actual behaviours. These observational data were taken from national statistics and not obtained through a dedicated survey, as the latter option would have been too difficult to perform. To find useful data on the subject, a literature survey was carried out, especially using databases from OECD and FAO, which list useful articles about the subject. Agronomics statistics on prices and the trade market were also used. The advantage of using observational data is that there is no risk that the collection of the data will influence the outcome of the data set. However, there could be a negative outcome of using observational data in that there could be causality between the variables in the data set. This was taken into account in the analysis. It could be difficult to find suitable data, but since there were reliable empirical data available for the study, the observational data were best suited.

Since a multiple regression analysis was made, a number of factors having an impact on the price of wheat were investigated (Table 1). Because only a few variables have data that can be used in this kind of survey, some variables are used to explain different types of factors. For example, the variable yield explains the factors weather, structural farm change and wheat stocks (Hintze-Gharres, 2014). Global factors could also affect the price of wheat in Sweden and were thus investigated in the analysis. These included the price of oil, increased demand from developing countries, differences in returns between the countries and demand on the major trading markets, for example the Paris stock market (Table 1). Wheat dominates world food trade and represents the largest world food export, with the majority of the exports coming from the USA, Canada, Australia, Argentina and France. The major importers are Latin America and the Caribbean (FAO, 2014). Sweden is a small country in this respect, which means that it is a price taker on the world market (Jordbruksverket, 2014). It is difficult to list all the variables that could have an effect on the price of wheat because they can be difficult to quantify or because trustworthy data are lacking. Therefore such variables were not included because they would have made the end results less trustworthy.

Table 1. Different variables suggested to determine fluctuations in the price of wheat in Sweden in the actual year of harvest and in the following year.

<b>Effect on price in the actual year</b>		
<i>Variable</i>	<i>Explanation and units</i>	<i>Expected effect on price</i>
Weather	Yield, total harvest in tonnes	Good weather for cropping wheat makes the price go down
Global price	Import/export quantity in tonnes	Low global price decreases the domestic price
Price of oilseeds	Import/export quantity in tonnes	Could be used as a substitute in ethanol production. Low price gives less demand for wheat
Price of diesel	Import/export quantity in tonnes	Could be used as a substitute in ethanol production. Low price gives less demand for wheat.
Structural farm change	Yield, total harvest in tonnes	Farms are getting larger, which could mean that the price will go down
Expected returns	Total production in tonnes	If there is an expected return, the price will be stable
Energy prices	Total production in tonnes	High energy prices will push the price up, fertiliser costs will rise and make wheat production more expensive
Wheat stocks	Yield, total harvest in tonnes	Large stocks will lower the price
<b>Effect on price in the following year</b>		
Weather	Yield, total harvest in tonnes	Good weather for cropping wheat makes the price go down
Global price	Import/export quantity	Low global price decreases the domestic price
Price of oilseeds	Import/export quantity in tonnes	Could be used as a substitute in ethanol production. Low price gives less demand for wheat
Price of diesel	Import/export quantity in tonnes	Could be used as a substitute in ethanol production. Low price gives less demand for wheat
Energy prices	Total production in tonnes	High energy prices will push the price up
Wheat stocks	Yield, total harvest in tonnes	Large stock will press the price down
<b>Effect on price over the longer term</b>		
Weather	Yield, total harvest in tonnes	Good weather for cropping wheat makes the price go down
Exchange rates	Import/export quantity in tonnes	Highly valued SEK gives less trade
Price of oilseeds	Import/export quantity in tonnes	Could be used as a substitute in ethanol production. Low price gives less demand for wheat
Price of diesel	Import/export quantity in tonnes	Could be used as a substitute in ethanol production. Low price gives less demand for wheat
Wheat stocks	Yield, total harvest in tonnes	Large stocks will press the price down

The main hypothesis for the explanatory variables is that yield probably has a negative correlation with price. If the yield is high there will be a large supply, which will cause the price to go down. Total production will probably have a positive correlation, since bad weather will decrease the supply and make the prices go up. Increasing prices of other fuels will also make the wheat price rise. Imports could theoretically have a negative correlation, since if Sweden imports large amounts the supply will increase, leading to a price increase. The opposite applies if Sweden exports large quantities of wheat.

There are five explanatory variables which will be used in the regression to declare the variation in the wheat price. These variables are listed in table 2, together with the summary statistics for each variable.

*Table 2. The chosen explanatory variables for the regression.*

	<i>Yield</i>	<i>Export</i>	<i>Import</i>	<i>Total Production</i>
Sum	39884450	8713298	1573622	40118700
Average	1994223	435664.9	78681.1	2005935
Minimum	1.3293e+006	52163	30660	1.3447e+006
Maximum	2.4123e+006	8.4096e+005	1.7913e+005	2.4123e+006
Unit	Total harvest in tonnes	Total yield in tonnes	Total yield in tonnes	Tonnes

The explanatory data (table 2) chosen for use in the analysis were taken from Swedish Board of Agriculture and FAO publications. These two sources were chosen because they represent the best datasets, as they cover the most years and the data collection method where reliable, for instance the variables where not collected by using the average. In the collection of the dataset a couple of other sources were also investigated, but these did not contain data for all the years to be taken into account in the analysis. There are still some limitations in the data collection in that the data are only going up to 2011 and statistics are lacking for 2012-2014. In all, there were five explanatory variables which were expected to have an impact on wheat prices. All the variables are calculated on an annual basis. In the model, the settlement price of wheat are included, since the results are intended mostly for the farmers and therefore this price will be most important. A settlement price is the price that the producer receives; it is also called the guarantee price (NE 2014).

## 5 Results

This chapter presents the relative value estimated for each variable. In all the regressions made, the price was explained by some chosen variables and the outcome indicated how each variable affected the price.

### 5.1 Empirical findings and results

The results from the regression are shown in Table 3. There, the four explanatory variables were lagged one year behind and both the dependent and independent variables were logarithmic.

The results showed that all the variables were significant except the lagged export variable. The level of significance varied between  $P < 0.01$  and  $P < 0.05$ . The value of  $R^2$  was 0.58, which can be seen as a trustworthy result for an economic calculation, where the end result often does not give such high values for  $R^2$ . The coefficients for import and export were lower than those for the other variables, which mean that they do not have as much impact on the price.

Table 3. Results of the regression, where the independent variables were lagged and logarithmic. \*\*\*significant at  $P < 0.01$ , \*\*significant at  $P < 0.05$ .

Variable	Coefficient	p-value	Significance
Constant	33,78080	<0,00001	***
Log yield	16,68440	0,01232	**
Log and lagged yield	27,79850	0,00215	***
Log export	0,20904	0,00816	***
Log and lagged export	-0,00575799	0,89194	
Log import	0,32832	0,03298	**
Log and lagged import	-0,26211	0,04495	**
Log total production	-17,34610	0,01126	**
Log and lagged total production	-29,20070	0,00165	***
$R^2$	0,58083	Adjusted R-squared	0,24550
Mean dependent variance	6,92086	S.D. dependent variance	0,29166
Sum squared residual	0,64181	S.E. of regression	0,25334
F(8, 10)	20,06033	P-value(F)	0,000033

## 5.2 Forecast

The estimated model in table 2 allows not only to determine the partial elasticities between the dependent variable and each explanatory variable, respectively, but also enables the forecast of wheat prices (Figure 8) for the next few years. The graph shows, The predicted price for wheat. The price forecast was calculated in Excel and gave the answer that one tonne wheat will sell at a price of 6, 8 monetary units. Since this is the logarithmic price, the value was converted to the natural price which gives the answer 897 SEK per tonnes.

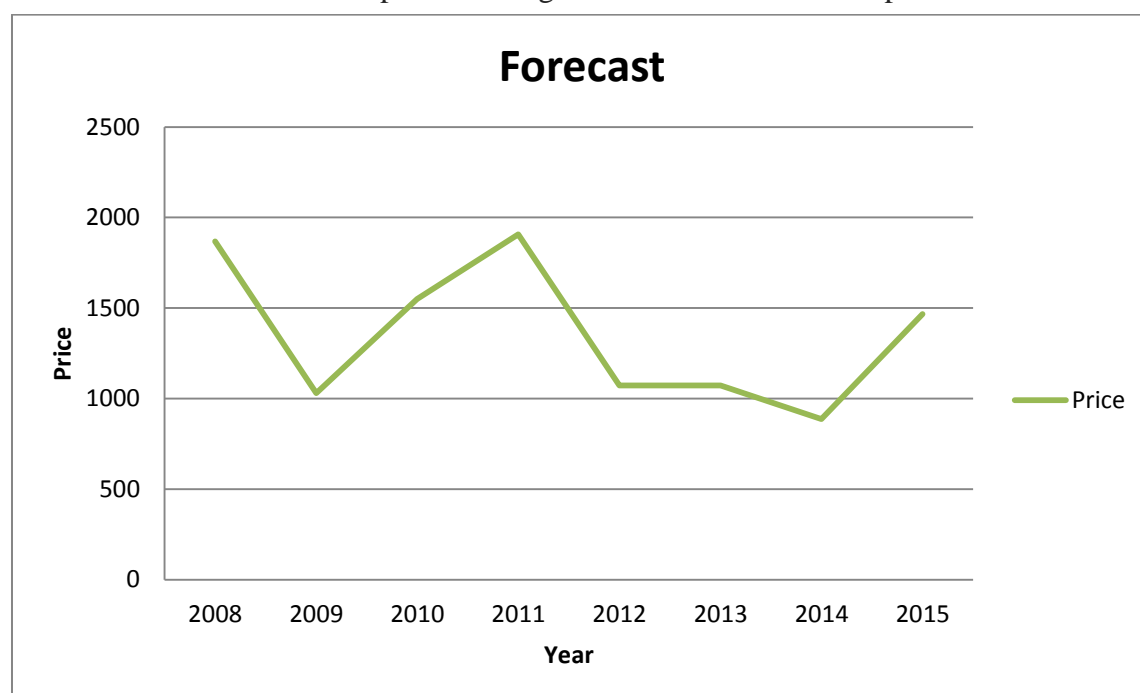


Figure 8. Forecasting the future price of wheat, where the independent variables were lagged and logarithmic.



## 6 Discussion and conclusions

The results from the regression analysis based on the reduced form partial equilibrium model showed that the price of wheat in Sweden is significantly dependent on all the variables tested except the export price in the previous year. That relationship turned out to be statistically insignificant.

According to the results, the demand for wheat determines the price. The demand in turn depends on a number of factors. All the factors tested here had a significant impact on wheat prices except the amount of export in the previous year. However, according to FAO and OECD reports, previous year exports also have an impact on price. This is probably due to some unobserved factors that are not captured in the model, such as storage and waste, which are variables FAO and OECD have included in their reports.

The yield in the actual year had a major influence on wheat prices, but the yield in the previous year had an even greater impact. A similar effect was found for total production, with total production in the previous year having the largest impact on wheat prices. The fact that yield influences the price means that weather, structural farm changes and wheat stocks have an impact on the price of wheat. These variables are fairly easy to understand and have historically often been used when forecasting grain prices, for example, *Svenska dagbladet* wrote earlier good weather in Sweden brings higher returns (Anonymous 2007). The fact that total production has a significant impact on price means that expected returns and energy prices from other energy sources also influence wheat prices. For these two variables, it is fairly easy to understand the correlation between their occurrence and the effect on the price.

Imports had a significant influence on price and exports in the actual year, although the coefficients were small and the percentage impact was not great. This means that the world market price, the price of other fuels and the exchange rate have an impact, although it does not appear to be very great.

One of the most interesting aspects of the results is that almost all the variables tested were found to affect prices most in the following year. This can make it easy for farmers to calculate the price for the next year, depending on how these factors have influenced the price. The total production variable gave a negative coefficient, meaning that the price will decrease as the value of this variable increases. The other variables had a positive coefficient, meaning that wheat prices will increase if one of these factors increases.

Looking at the present results and the data from FAO that were investigated for the study, the conclusion which can be drawn regarding Sweden's entry into the EU is that membership has not had any impact on wheat prices in Sweden. There has also been no change in wheat trade before and after Sweden joined the EU. This lack of change in trade can be seen as both positive and negative. One of the main reasons why Sweden decided to join the EU was to improve trade and relations with other countries. One could have expected an improvement in Swedish wheat trade, since wheat is a major commodity on the world market. However, Sweden still uses its own currency (SEK) and not EUR, which could have generated currency costs in trade with EU countries, despite Sweden being part of the EU. The other EU countries which sell wheat in EUR have the same conditions and could outcompete the Swedish trade, although this does not appear to have occurred to date.

Future prospects in Sweden and how best to manage the market situation can be assessed using the information obtained. By knowing the factors on which wheat prices are dependent, Sweden can become more competitive on the world market and strengthen its trade with other countries. Thus with more insights on what the market is demanding, Sweden can have more profitable trade with other countries.

Since there are some limitations in the method, for example that the variables are independently chosen as shown in part 4, future research on how the market integrates with other grain markets would probably be useful. Some research is needed on how best to use the information presented here in political decisions concerning the market and Swedish farmers. This study did not examine whether wheat prices are influenced by specific neighbouring countries, which is also a factor that could affect the price.

The findings of the study are useful in providing farmers with a deeper understanding of the market conditions for selling wheat. In addition, some policy makers could be interested in the results because the wheat market is strongly regulated and information about trade on this market can allow policies to be developed to influence the market in a more beneficial way. The market is regulated because Sweden wants *e.g.* to secure farmers' income and ensure that there is enough food domestically (Swedish Ministry of Agriculture and Forestry, 2011). The regulations existing today on the market are import protection, export subsidies and intervention. The EU has the goal of reducing regulations to make trade between countries easier, which could be done in the best way with more information about the market.

In the long run, the approach presented here can be used to improve living conditions for farmers due to better market information and better policy implementations. This in turn is good for the country and for consumers, as they can buy wheat at what they know to be a reasonable price.

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